National Aeronautics and Space Administration

Major NASA Development Programs
Program Cost Estimates

This special section of the FY 2000 budget justifications provides information about major NASA programs that are either in the design and development phase or have not completed their initial operational phase. In several instances, information about programs which are not "major" but are of special interest has been included. The budgetary estimates are expressed in millions of dollars of *budget authority*. * Estimates of the FY 1998 and prior fiscal year budget authority are the "actual" amounts. The FY 1999 amounts are consistent with the FY 1999 initial operating plan. The amounts for FY 2000 and future fiscal years are expressed in "real year" economics, that is, they include an adjusting factor for the future inflation expected to be experienced. If the term "constant dollars" is used in the budget justifications, that phraseology indicates that the numbers do not include inflationary adjustments beyond the fiscal year referenced (e.g., "constant FY 1994 dollars").

The estimates provided below are intended to be comprehensive, including all related mission-unique costs, but there are limitations. The direct and indirect costs incurred by foreign governments or other federal agencies in support of these missions have not been included. (The reader is referred to the NASA Program Status Reports, a biannual document published by NASA, for the most accurate information available to NASA on the amounts incurred or to be incurred.) The estimates of civil service costs have been included, but these estimates should be considered preliminary, and they will continue to be refined as the agency moves toward full cost accounting over the next two years.

* *Budget authority* is a term used to represent the amounts appropriated by the Congress in a given fiscal year; *budget authority* provides government agencies with the authority to obligate funds. The ensuing obligations, cost incurrence, and expenditures (outlays) can differ in timing from the fiscal year in which Congress provides the *budget authority* in an appropriations act.

High Speed Research Program

While NASA was on track to meet the original High Speed Research Program goals, technology advancements in subsonic commercial transports have resulted in a much quieter fleet. As a result, the original noise requirements are now insufficient for the HSCT to blend into the surrounding aircraft noise levels. Although dramatic advances were made against the original program goals, the recent application of more stringent noise constraints to ensure an environmentally compatible high-speed civil transport (HSCT) led to designs that require significant advances in propulsion technology. Our industry partners indicated that product development would be significantly delayed leading to the decision to terminate the focused HSR program at the end of FY 1999.

NASA's HSR program has made significant contributions to aeronautics state of the art. It has provided a public-sector catalyst in addressing this important opportunity with U. S. industry through a two-phase approach. The first phase, successfully completed in 1994, defined HSCT environmental compatibility requirements in the critical areas of atmospheric effects, community noise and sonic boom and Several milestones—including completion of a preliminary noise assessment; selection of engine cycle, inlet, and nozzle concept; selection of candidate flight deck concepts; identification of preliminary wing and fuselage structural concepts; and, ultimately, definition of a technology concept—contributed to a technology foundation that provided confidence that the necessary technology could be developed. The second phase was a cooperative program with U. S. industry, directed at developing and validating designs, design methodologies and manufacturing process technology for subsequent application by industry in future HSCT aircraft programs to ensure environmental compatibility and economic viability. As HSR Phase II is concluded, it will have exceeded the original HSR Phase II program goals planned through FY 1999 for environmental compatibility and economic viability. As an example of the highly successful nature of this program, the technology concept airplane (TCA) baseline defined in December 1998 is several decibels quieter than the original HSR noise goals. Accomplishments contributing to TCA definition include successful completion of subscale combustor tests and large-scale nozzle tests; selection of turbine airfoil alloy and turbomachinery disk material; selection of a combustor configuration; completion of wing and fuselage subcomponent tests; and completion and evaluation of supersonic laminar flow control tests.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	1134.5	245.0	180.7							1560.2
(ESTIMATED CIVIL SERVICE FTEs)	(3,025)	(506)	(402)							
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	197.1	41.5	34.0							

Advanced Subsonic Technology

The AST program was planned and designed to develop, in partnership with the FAA, the U.S. aeronautics industry and universities, high-payoff, high-risk technologies to enable a safe, highly productive global air transportation system that includes a new generation of environmentally compatible, operationally efficient U.S. subsonic aircraft. The critical needs were selected on the basis of industry/FAA technology requirements to provide a focused and balanced foundation for U.S. leadership in aircraft manufacturing, aviation system safety, and protection of the environment.

The AST Program consisted of 5 elements: Safety, Environment, Economics, Reduced Seat Cost, and Capacity. Due to other pressing Agency needs in general and aeronautics needs in particular, the AST program will be concluded in FY 1999. However, the Capacity element is now identified as a separate focused program, "Aviation System Capacity" and is described separately. Aggressive technology transition plans for the conclusion of the remainder of the AST elements were pursued in order to mitigate the significant risk to successful technology transfer to industry as a result of early termination. Budgetary constraints notwithstanding, the AST program has been successful and progress was made toward meeting the current program goals.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	443.2	144.4	89.6							677.2
(ESTIMATED CIVIL SERVICE FTEs)	(1,883)	(352)	(324)	(7)	(7)	(7)	(7)	(7)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	126.3	28.8	27.4	0.6	0.6	0.7	0.7	0.7		

Aviation System Capacity

The goal of the Aviation System Capacity (ASC) program, formerly an element within the Advanced Subsonic Technology Program, is to enable safe increases in the capacity of major US and International Airports through both modernization and improvements in the Air Traffic Management System and the introduction of new vehicle classes which can potentially reduce congestion, specifically: to increase National Airspace System (NAS) throughput while assuring no degradation to safety or the environment; to increase the flexibility and efficiency of operations within the NAS for all users of aircraft, airports and airspace; and to reduce system inefficiencies.

The ASC program is composed of the Terminal Area Productivity (TAP), Advanced Air Transportation Technology (AATT), and the Civil Tiltrotor (CTR) projects. The TAP project develops technology and procedures to support the aviation systems infrastructure by reducing system delays and enabling new modes of airport operation to support "Free Flight". The AATT project develops decision making technologies and procedures to provide all airspace users with more flexibility and efficiency, as well as enable new modes of operation that support the FAA commitment to "Free Flight". The CTR project develops technologies and procedures to overcome inhibitors to a civil tiltrotor operating within an improving and modernized air traffic system. The ASC program works closely with manufacturers, the airlines and the FAA, the technology customers, who are responsible for applying the candidate technologies as operational systems.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	132.7	56.7	53.9	60.0	59.2	77.6	71.6	53.1		564.8
(ESTIMATED CIVIL SERVICE FTEs)		(192)	(203)	(207)	(203)	(203)	(197)	(197)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		15.7	17.2	18.5	18.7	19.5	19.9	20.8		

X-33 Advanced Technology Demonstrator

The X-33 program will demonstrate, on the ground and on a flight demonstration vehicle, technologies and operations concepts that could reduce space transportation costs to one-tenth of their current level. The X-33 program includes two major decision points. The first decision, whether to proceed with the demonstration phase (Phase II), was made in July 1996 based on specific programmatic, business planning and technical criteria which had previously been agreed upon by NASA, the Office of Management and Budget and the Office of Science and Technology Policy. With Administration approval, Lockheed Martin Skunkworks, Palmdale, CA was chosen as the X-33 industry partner. X-33 flight tests are expected to begin in July, 2000. This date represents a slip of one year since the last budget was presented to Congress. The delay is due to technical and schedule problems. The second decision will be made at the end of the decade. X-33 ground and flight demonstrations, RLV business planning, the Future Space Launch Studies and other X-vehicles will provide the basis for an end-of-the-decade decision called for in the 1994 National Space Transportation Policy on an appropriate strategy for significantly reducing NASA's launch costs. At that time Government and industry may decide to pursue the full-scale development of an operational RLV.

NASA is utilizing an innovative management strategy for the X-33 program, based on industry-led cooperative agreements. As a result of industry's leadership of the program, Government participants are acting as partners and subcontractors, performing only those tasks for which they offer the most effective means to accomplish the program's goals. The Government participants report costs and manpower to the industry team leader as would any other subcontractor. Every NASA center except the Goddard Space Flight Center has a negotiated role on the X-33 program. The Industry-led cooperative arrangement allows a much leaner management structure, lower program overhead costs and increased management efficiency

The X-33 program also funds refurbishment of rocket engine test stands at Stennis in FY 1997 ($2.3 million) and FY 1998 ($3.7 million) to enable testing of X-33 development and flight engines, as well as other future advanced space transportation engines. Civil Service estimates below are for the X-33 cooperative agreement only.

A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
COOPERATIVE AND TASK AGREEMENTS	262.1	298.6	239.1	111.6						911.4
OTHER X-33 ACTIVITIES	249.6	19.7	38.2							307.5
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	511.7	318.3	277.3	111.6						1218.9
(ESTIMATED CIVIL SERVICE FTEs)	(335)	(404)	(329)	(183)	(70)	(13)	(13)	(13)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	26.1	33.1	27.8	16.4	6.5	1.3	1.3	1.4		

Alternate Turbopump Development

Funding to begin development of an alternate design for the two turbopumps driving the Space Shuttle's Main Engine was initiated in FY 1987. The development of a new high-pressure oxygen turbopump and hydrogen fuel turbopump was undertaken to improve the safety, reliability, producibility, and maintainability of the current turbopumps. After an initial period of design and development, problems experienced in early development testing and accompanying increased costs resulted in suspension of the fuel turbopump's development, while development activities concentrated on the oxygen turbopump. Although further development problems were encountered with the oxygen turbopump, their successful resolution led to Congress agreeing in Spring 1994 to resumption of the fuel turbopump's development. The first flight of the oxygen turbopump occurred in 1995, and the initial flight of the fuel pump is currently planned for late 1999, rescheduled from late 1997 due to development problems. The budgetary estimate of $956.3 million includes not only the funding required for the design, development, and extensive testing of these two types of turbopumps, but also the funding needed to produce the flight turbopumps for installation into the main engines for the four-orbiter fleet.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for the use of government facilities and general and administrative support used to carry out the development. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	668.5	28.6	16.9	8.5					28.5	751.0
IMPLEMENTATION	116.7	27.9	40.0	20.7						205.3
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	785.2	56.5	56.9	29.2					28.5	956.3
(ESTIMATED CIVIL SERVICE FTEs)	(509)	(30)	(20)	(10)						
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	30.0	2.5	1.7	0.9						

Super Lightweight Tank

The objective of the Super LightWeight Tank (SLWT) is to provide the Space Shuttle with 7,500 pounds of additional performance of payload capability. The weight reduction objective was achieved by selectively substituting high-strength, low-density, aluminum-lithium alloys, redesigning certain structural components, and reducing thermal protection thickness. The new SLWT physically and functionally replaced the existing External Tank (ET) with not launch processing impacts and without detriment to the other Shuttle system elements. NASA was given congressional approval to proceed in January 1994. The External Tank Project Office at the Marshall Space Flight Center in Alabama manages the SLWT, and Lockheed Martin is the ET prime contractor. The first flight of the SLWT (STS-91) was on June 2, 1998. In addition to the design and development costs, the figures shown below as "recurring cost" provide the estimate of the funding required for the external tank program's production of the new tanks. The estimates include the additional material cost which will be incurred in the production of subsequent tanks. The aluminum-lithium material is a specialty metal produced to rigorous specifications and accordingly costs more than the aluminum used at present. The development cost estimate is significantly reduced from the FY 1998 estimate, as contract performance exceeded expectations and project reserves were not required.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for the use of government facilities and general and administrative support used to carry out the development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT COST	126.7	0.7								127.4
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	126.7	0.7								127.4
(ESTIMATED CIVIL SERVICE FTEs)	(202)	(29)								
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	14.7	2.4								

Checkout and Launch Control System (CLCS)

A new Checkout and Launch Control System (CLCS) was approved for development at KSC in FY 1997. The CLCS will upgrade the Shuttle launch control room systems with state-of-the-art commercial equipment and software in a phased manner to allow the existing flight schedule to be maintained. The CLCS will reduce operations and maintenance costs associated with the launch control room by as much as 50%, and will provide the building blocks to support future vehicle control system requirements. The Thor and Atlas phases were completed in FY 1998. During these phases, the initial applications for the Orbiter Processing Facility were developed, the math models were validated, Shuttle Avionics Integration Lab interfaces were established, and hardware testing was done. The Titan and Scout phases of CLCS are planned for FY 1999 during which Orbiter automated power-up will be developed, peripheral locations will be upgraded, and selected vertical testing will be done. In FY 2000, the Delta and Saturn phases will be accomplished which includes completion of all launch application development, completion of software certification and validation, and a complete integrated flow demonstration. Since the FY 1999 Budget, software independent validation and verification (IV&V) performed by Ames Research Center was also added to this project. By the end of FY 2000, Operations Control Room-1 will be fully operation, followed by certification in FY 2001. The first Shuttle launch using the CLCS is scheduled for FY 2001 with full implementation to be completed one year later.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for the use of government facilities and general and administrative support used to carry out the development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT COSTS	22.6	41.0	48.0	48.3	36.1	11.4				207.4
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	22.6	41.0	48.0	48.3	36.1	11.4				207.4
(ESTIMATED CIVIL SERVICE FTEs)	(50)	(105)	(135)	(131)	(77)					
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	3.7	8.6	11.4	11.7	7.1					

TDRS Replenishment Spacecraft Program

The Tracking and Data Relay Satellite (TDRS) Replenishment Spacecraft program ensures sufficient spacecraft will be available to continue Space Network operations into the next century. The program provides three additional TDRS satellites and ground terminal modifications through a fixed price, commercial practices contract with Hughes Space and Communications Company. This innovative approach has deleted or greatly reduced Government specifications and documentation requirements, allowing the contractor to substitute commercial practices; this has resulted in efficiencies in both cost and development lead time.

These satellites will incorporate Ka-band frequencies, where space research has a primary allocation, into the high data rate services provided via the high gain, single access antennas. The single access services at S-band and Ku-band will be retained, remaining backward compatible with the existing, first generation TDRS satellites. These satellites will also provide an enhanced multiple access service with data rates up to three megabits per second. The first spacecraft remains on schedule for launch in the third quarter of 1999.

The estimates do not include costs for use of government facilities and general and administrative support used to carry out the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification fo the program within the Space Communications section.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
SPACECRAFT DEVELOPMENT AND GROUND TERMINAL MODIFICATIONS	356.9	56.0	66.7	17.7	14.5	57.7	6.5			576.0
LAUNCH SERVICES	24.7	52.0	34.8	13.5	40.5	67.8	37.0			270.3
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	381.6	108.0	101.5	31.2	55.0	125.5	43.5			846.3
(ESTIMATED CIVIL SERVICE FTEs)	(119)	(41)	(39)	(43)	(42)	(42)	(42)	(7)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	8.0	3.4	3.3	3.8	3.9	4.0	4.2	0.7		

Advanced X-Ray Astrophysics Facility

The design and development of the Advanced X-Ray Astrophysics Facility (AXAF) was approved by Congress in the FY 1989 budget. The AXAF is the third of the four "Great Observatories" intended to observe the universe in four electromagnetic spectrum regions: visible, infrared, gamma ray, and x-ray. The initial phase of the AXAF's development was limited to a feasibility demonstration of the new mirror technology required to achieve the AXAF's objectives. A specially designed x-ray calibration facility was constructed to assure the mirrors meet their design specifications. The second phase was approved by Congress after the demonstration mirrors were successfully tested. In 1992, NASA management directed the restructuring of the AXAF program to reduce projected future funding requirements. A two-spacecraft approach was selected, a large imaging spacecraft (**AXAF-I**maging) and a smaller spectroscopy spacecraft (**AXAF-S**pectroscopy). In 1993, Congress directed the elimination of the AXAF-S. The current launch date for the AXAF-I is April 1999 aboard the Space Shuttle, with an Inertial Upper Stage (IUS) providing delivery into a highly elliptical orbit around the Earth. This date represents a slip of approximately 4 months since the FY 1999 budget was sent to Congress, as previously reported in a letter to the Committees on November 13, 1998. The slip resulted from the need to perform additional software development and testing, as well as from NASA's desire to gain assurance that the spacecraft systems and operating procedures have been tested sufficiently to enable a successful mission. Moreover, in mid-January 1999, following the successful completion of AXAF testing, TRW discovered a problem with circuit boards on some of their spacecraft, including AXAF. The project is currently investigating the extent of the problem on AXAF; however, it appears that the minimum launch delay will be five weeks, or until May 1999. The potential exists for a much longer delay, but at this time the scope of the problems, and the length of the delay, are yet to be determined. NASA will not launch AXAF until we are certain that we have a world-class observatory that has been thoroughly tested and meets all requirements. NASA will inform the Administration and Congress of the new AXAF launch date as soon as possible.

The budgetary estimates provided below encompass: the early development of the mirror technology; the design and development phase; establishment of a mission-unique science center and preflight ground system development, followed by a five-year period (1999-2003) of mission operations and science data analysis; the purchase of the IUS and integration activities; the average cost (including recurring costs for improvements and upgrades) of an FY 1998 Space Shuttle flight; mission-unique tracking and data support costs; and, the construction of the X-Ray Calibration Facility. The estimates below also include a pro forma distribution of the average costs of a Space Shuttle. They do not include the amounts being contributed by international participants, or for the use of non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
ADVANCED TECH DEVELOPMENT	54.2									54.2
DEVELOPMENT	1,365.8	103.9	39.0							1,508.7
MISSION OPS & DATA ANALYSIS	128.4	41.5	55.5	60.5	59.7	61.6	59.7	49.2	225.2	741.3
UPPER STAGE	65.6	8.3	2.0							75.9
STS LAUNCH SUPPORT	191.5	76.5	114.9							382.9
TRACKING & DATA SUPPORT	1.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	3.0
CONSTRUCTION OF FACILITIES	17.7									17.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	1,824.4	230.5	211.6	60.7	59.9	61.8	59.9	49.4	225.5	2,783.7
(ESTIMATED CIVIL SERVICE FTEs)	(1,528)	(123)	(125)							
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	96.9	10.1	10.6							

Space Infrared Telescope Facility (SIRTF)

The purpose of the Space Infrared Telescope Facility (SIRTF) mission is to explore the nature of the cosmos through the unique windows available in the infrared portion of the electromagnetic spectrum. SIRTF is the fourth of NASA's Great Observatories, which include the Hubble Space Telescope, the Compton Gamma Ray Observatory, and the Advanced X-Ray Astrophysics Facility. The funding plan provided below reflects a dramatic restructuring of the SIRTF design concept carried for many years. Rather than simply "descoping" the "Great Observatory" concept to fit within a $400 million (FY94 $) cost ceiling imposed by NASA, scientists and engineers have instead redesigned SIRTF from the bottom-up. The goal was to substantially reduce costs associated with every element of SIRTF -- the telescope, instruments, spacecraft, ground system, mission operations, and project management. The Jet Propulsion Laboratory (JPL) was assigned responsibility for managing the SIRTF project. SIRTF is planned for launch on a Delta launch vehicle during FY 2002.

The budgetary estimates below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out prior to FY 96. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
ATD	39.9	40.0								79.9
DEVELOPMENT		70.2	111.7	101.1	90.6	19.2				392.8
MISSION OPS & DATA ANALYSIS						20.0	79.0	71.0	184.3	354.3
LAUNCH SUPPORT			8.0	23.9	26.2	11.0				69.1
TRACKING & DATA SUPPORT				tbd	tbd	tbd	tbd	tbd	tbd	tbd
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		110.2	119.7	125.0	116.8	50.2	79.0	71.0	184.3	896.1
(ESTIMATED CIVIL SERVICE FTEs)	(29)	(34)	(33)	(27)	(9)	(3)	(2)	(1)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	2.2	2.8	2.8	2.4	0.8	0.3	0.2	0.1		

Relativity Mission/Gravity Probe-B

The development of the Relativity mission began in 1993, after many years of studying mission design alternatives and developing the advanced technologies required for this mission to verify Einstein's theory of general relativity. The award of the spacecraft development contract was made in 1994. The scheduled launch date is October 2000, using a Delta II launch vehicle. This launch date coincides with the original baseline date for launch of the Relativity Mission. The FY 1999 budget forecast a March 2000 launch, assuming that the program would not consume its schedule reserves. In the past year, however, the project has encountered, and resolved, several technical problems which have resulted in the consumption of those reserves.

The estimates provided below include funding for the experiment development activities, a minimum of 16 months of mission operations, and the launch services. These estimates are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out from FY 1985-87, but they do provide the amounts for the Shuttle Test of Relativity Experiment program initiated in FY 1988 and subsequently restructured into a ground test program only. The estimates also exclude the non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	330.9	57.3	42.6	25.7	5.4					461.9
MISSION OPS & DATA ANALYSIS					9.1	6.3	4.1			19.5
LAUNCH SUPPORT	10.6	13.5	14.8	14.8						53.7
TRACKING & DATA SUPPORT							TBD			TBD
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	341.5	70.8	57.4	40.5	14.5	6.3	4.1			535.1
(ESTIMATED CIVIL SERVICE FTEs)	(90)	(8)	(10)	(7)						
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	5.6	0.7	0.8	0.6						

Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED)

The TIMED mission is the first science mission in the Solar Terrestrial Probes (STP) Program, and is part of NASA's initiative aimed at providing cost-efficient scientific investigation and more frequent access to space. TIMED will be developed for NASA by the Johns Hopkins University Applied Physics Laboratory (APL). The Aerospace Corporation, the University of Michigan, NASA's Langley Research Center with the Utah State University's Space Dynamics Laboratory, and the National Center for Atmospheric Research will provide instruments for the TIMED mission.

TIMED is scheduled for launch in May 2000 aboard a Med-Lite Class launch vehicle. TIMED began its 36-month C/D development period in April 1997. The budgetary estimates below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out from April 1996 to April 1997.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	25.9	55.7	37.8	9.9						129.3
MISSION OPS & DATA ANALYSIS				8.7	11.3	8.8	6.6	2.8		38.2
LAUNCH SUPPORT	4.4	8.7	11.5	6.1						30.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	30.3	64.4	49.3	24.7	11.3	8.8	6.6	2.8		198.2
(ESTIMATED CIVIL SERVICE FTEs)	(21)	(12)	(15)	(16)	(7)	(8)	(5)	(5)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	1.6	1.0	1.3	1.4	0.6	0.8	0.5	0.5		

The Explorer Program

The Explorer program consists of small to mid-sized spacecraft conducting investigations in all space physics and astrophysics disciplines. The program provides for frequent, relatively low-cost missions to be undertaken as funding availability permits within an essentially level overall funding profile for the program. The funding profile provided below covers the design and development phase, launch services, mission-unique tracking and data acquisition support, mission operations and data analysis. It does not include costs for the use of government facilities and general and administrative support required to implement the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
Far Ultraviolet Spectroscopy Explorer	105.5	38.4	26.5	13.4	14.4	7.0				205.2
Imager for Magnetospause-to-Aurora Global Exploration	39.6	39.2	42.2	14.0	7.1	7.1	2.5	1.0		152.7
Microwave Anisotropy Probe	22.5	26.0	40.1	33.8	20.3	3.7	2.6			149.0
*SWAS, TRACE, WIRE	176.2	33.5	17.9	7.4	7.4	3.5	0.4			246.3
HESSI, GALEX, TWINS, BOLT (New SMEX)		25.5	57.8	45.0	26.3	8.7	8.7	5.5		177.5
*STEDI (SNOE, TERRIERS, CATSAT)	35.1	1.2	5.5	1.0	0.1					42.9
*HETE-II	1.4	7.5	7.2	1.5	1.5					19.1
*Planning & Future Developments		3.1	20.6	63.4	127.0	182.0	243.6	282.5	CONT	
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		174.4	217.8	179.5	204.1	212.0	257.8	289.0	CONT	
(ESTIMATED CIVIL SERVICE FTEs)	(2,081)	(250)	(184)	(132)	(53)	(31)	(34)	(28)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		20.5	15.5	11.8	4.9	3.0	3.4	3.0		

*Tracking estimate is not included

Far Ultraviolet Spectroscopic Explorer

Development on the Far Ultraviolet Spectroscopy Explorer (FUSE) began in FY 1996. The FUSE mission was restructured from a Delta-class explorer in order to reduce costs and accelerate the launch date from CY 2000 to November 1998. As a result of technical difficulties encountered, particularly with the spacecraft gyros, the launch date has been delayed until May 1999. FUSE is being managed by Johns Hopkins University, with contributions from the University of Colorado, the University of California-Berkeley, Orbital Sciences Corp., Canada and France.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	84.4	22.1	14.8							121.3
MISSION OPS & DATA ANALYSIS		0.3	10.6	13.4	14.4	7.0				45.7
LAUNCH SUPPORT	21.1	16.0	1.1							38.2
TOTAL	105.5	38.4	26.5	13.4	14.4	7.0				205.2

Imager for Magnetopause-to-Aurora Global Exploration

Development on the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) began in FY 1997. The IMAGE mission will use three-dimensional imaging techniques to study the global response of the Earth's magnetosphere to variations in the solar wind, the stream of electrified particles flowing out from the Sun. The magnetosphere is the region surrounding the Earth controlled by its magnetic field and containing the Van Allen radiation belts and other energetic charged particles. Southwest Research Institute has been selected to develop the IMAGE mission. IMAGE is scheduled for launch in February 2000 aboard a Delta-7326 (Med-Lite Class ELV).

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	32.3	26.4	17.2	7.7						83.6
MISSION OPS & DATA ANALYSIS				4.6	7.1	7.1	2.5	1.0		22.3
LAUNCH SUPPORT	7.3	12.8	25.0	1.7						46.8
TOTAL	39.6	39.2	42.2	14.0	7.1	7.1	2.5	1.0		152.7

Microwave Anisotropy Probe

Development on the Microwave Anisotropy Probe (MAP) began in FY 1997. The MAP mission will undertake a detailed investigation of the cosmic microwave background to help understand the large-scale structure of the universe, in which galaxies and clusters of galaxies create enormous walls and voids in the cosmos. GSFC is developing the MAP instruments in cooperation with Princeton University. MAP will launch in November 2000 aboard a Delta-7326 (Med-Lite Class ELV).

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	21.1	19.8	18.8	18.2	10.4					88.3
MISSION OPS & DATA ANALYSIS				0.9	4.2	3.7	2.6			11.4
LAUNCH SUPPORT	1.4	6.2	21.3	14.7	5.7					49.3
TOTAL	22.5	26.0	40.1	33.8	20.3	3.7	2.6			149.0

Stratospheric Observatory for Infrared Astronomy

The initial development funding for the Stratospheric Observatory for Infrared Astronomy (SOFIA) was requested in the FY 1996 budget. This new airborne observatory will provide a significant increase in scientific capabilities over the Kuiper Airborne Observatory, which was retired in October, 1995. The SOFIA will be accommodated in a Boeing 747 and will feature a 2.5-meter infrared telescope to be provided by the German Space Agency (DARA). SOFIA will conduct scientific investigations at infrared and submillimeter wavelengths. The initial science flights for SOFIA are scheduled to occur in October 2001; however, delays in development of the German telescope assembly are currently expected to result in a slip of several months.

The budget estimates provided below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the costs of preliminary design studies carried out in previous years, the amounts being contributed by the international participants, or costs for the use of government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Suborbital program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	51.3	45.8	58.2	45.1	34.4	36.6				271.4
MISSION OPERATIONS							38.0	38.9	CONT.	CONT.
TOTAL EXCLUDING CIVIL SERVICE COSTS	51.3	45.8	58.2	45.1	34.4	36.6	38.0	38.9		
(ESTIMATED CIVIL SERVICE FTEs)	(83)	(38)	(51)	(40)	(20)	(20)	(20)	(20)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	6.2	3.1	4.3	3.6	1.8	1.9	2.0	2.1		

Discovery Missions

Discovery missions are planetary exploration missions designed with focused science objectives that can be met with limited resources. Total development costs are not to exceed $150 million in constant FY 1992 dollars, and development schedules are limited to three years or less. Three Discovery missions have been launched: NEAR in February 1996, Mars Pathfinder in December 1996 and Lunar Prospector in January 1998. In addition, there are two Discovery missions currently in development (Stardust and Genesis), and one in planning (CONTOUR). Other future Discovery missions will be undertaken after selection through a peer review process.

The budgetary estimates provided below are the amounts included in the specific budget justification for this program within the Space Science section in the Science, Aeronautics and Technology appropriation. Under the specific mission descriptions, see below, other direct program cost elements are included: the development of the spacecraft and experiments, one year of mission operations, the launch services, and unique tracking and data acquisition services. They do not include costs for the use of government facilities and general and administrative support required to implement the program. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
NEAR	176.7	11.2	14.6	8.8	0.2					211.5
LUNAR PROSPECTOR	57.0	4.7	2.2							63.9
STARDUST	94.3	56.2	25.8	3.5	3.7	3.7	5.0	4.0	13.8	210.0
GENESIS	0.8	41.0	82.9	50.2	18.3	6.9	7.0	3.3	3.5	213.9
CONTOUR	0.4		8.4	51.8	45.6	21.1	3.7	3.0	9.9	143.9
FUTURE MISSIONS		2.4	11.3	78.5	93.3	173.0	217.9	214.4		
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	329.2	115.5	145.2	192.8	161.1	204.7	233.6	224.7		
(ESTIMATED CIVIL SERVICE FTEs)	(54)	(15)	(21)	(18)	(17)	(16)	(10)	(10)	Cont.	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	3.9	1.2	1.8	1.6	1.6	1.5	1.0	1.1	Cont.	

Near-Earth Asteroid Rendezvous (NEAR)

The NEAR was approved as a new start in FY 1994 as one of the initial Discovery Program missions. The NEAR mission was conducted as an in-house effort at the Applied Physics Laboratory, with many subcontracted subsystems. The NEAR spacecraft will conduct a comprehensive study of the near-Earth asteroid 433 Eros, including its physical and geological properties and its chemical and mineralogical composition. The NEAR spacecraft was launched February 17,1996 on a Delta II launch vehicle. The original opportunity to rendezvous with the asteroid in January 1999 was recently lost when the spacecraft failed to fire its main engine properly. However, a subsequent firing was successful, and NEAR will rendezvous with Eros in February 2000. The cost impact of extending the mission by 13 months has not yet been negotiated, and will be incorporated in future budget plans.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	124.9									124.9
MISSION OPS & DATA ANALYSIS	8.0	11.0	14.4	8.6						42.0
LAUNCH SUPPORT	43.5									43.5
TRACKING & DATA SUPPORT	0.3	0.2	0.2	0.2	0.2					1.1
TOTAL	176.7	11.2	14.6	8.8	0.2					211.5

Lunar Prospector

Lunar Prospector was selected as the third Discovery mission in FY 1995, and Phase C/D development started in the first quarter of FY 1996. The mission is designed to search for resources on the Moon, with special emphasis on the search for water in the shaded polar regions. Ames Research Center is managing the mission, and Lockheed Martin will provide the spacecraft, instruments, launch and operations. Launch on a Lockheed Launch Vehicle-II (LLV-II) occurred in January 1998, and the primary mission has been completed successfully. Launch costs are included in the development cost. Tracking and communications support are provided by the Deep Space Network.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	56.2	0.4								56.6
MISSION OPS & DATA ANALYSIS	0.8	4.3	2.2							7.3
TOTAL	57.0	4.7	2.2							63.9

Stardust

The Stardust mission was selected as the fourth Discovery mission in November 1995, with mission management from the Jet Propulsion Laboratory. The mission team completed the Phase B analysis, and Stardust was approved for implementation in October 1996. The mission is designed to gather samples of dust from the comet Wild-2 and return the samples to Earth for detailed analysis. The mission will also gather and return samples of interstellar dust that the spacecraft encounters during its trip through the Solar System to fly by the comet. Stardust will use a new material called aerogel to capture the dust samples. In addition to the aerogel collectors, the spacecraft will carry three additional scientific instruments. An optical camera will return images of the comet; the Cometary and Interstellar Dust Analyzer (CIDA) is provided by Germany to perform basic compositional analysis of the samples while in flight; and a dust flux monitor will be used to sense particle impacts on the spacecraft. Stardust will be launched on the Med-Lite expendable launch vehicle in February 1999 with return of the samples to Earth in January 2006.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
PHASE A/B	9.6									9.6
DEVELOPMENT	65.7	42.3	9.8							117.8
MISSION OPS & DATA ANALYSIS			3.5	3.5	3.7	3.7	5.0	4.0	13.8	37.2
LAUNCH SUPPORT	19.0	13.9	12.5							45.4
TOTAL	94.3	56.2	25.8	3.5	3.7	3.7	5.0	4.0	13.8	210.0

Genesis

In October 1997 NASA selected Genesis as the fifth Discovery mission. The Genesis mission is designed to collect samples of the charged particles in the solar wind and return them to Earth laboratories for detailed analysis. It is led by Dr. Donald Burnett from the California Institute of Technology, Pasadena, CA; JPL will provide the payload and project management, while the spacecraft will be provided by Lockheed Martin Astronautics of Denver, CO. Due for launch in January 2001, it will return the samples of isotopes of oxygen, nitrogen, the noble gases, and other elements to an airborne capture in the Utah desert in August 2003. Such data are crucial for improving theories about the origin of the Sun and the planets, which formed from the same primordial dust cloud.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
PHASE A/B	0.3	11.1								11.4
DEVELOPMENT		20.3	65.1	33.2	7.3					125.9
MISSION OPS & DATA ANALYSIS					10.5	6.4	6.5	3.3	3.5	30.2
LAUNCH SUPPORT	0.5	9.6	17.8	17.0						44.9
TRACKING & DATA SUPPORT					0.5	0.5	0.5			1.5
TOTAL	0.8	41.0	82.9	50.2	18.3	6.9	7.0	3.3	3.5	213.9

Comet Nucleus Tour (CONTOUR)

In October 1997 NASA selected CONTOUR as the sixth Discovery mission. CONTOUR's goals are to dramatically improve our knowledge of key characteristics of comet nuclei and to assess their diversity. The spacecraft will leave Earth orbit, but stay relatively near Earth while intercepting at least three comets. The targets span the range from a very evolved comet (Encke) to a future "new" comet such as Hale-Bopp. CONTOUR builds on the exploratory results from the Halley flybys, and will extend the applicability of data obtained by NASA's Stardust and ESA's Rosetta to broaden our understanding of comets. The Principal Investigator is J. Veverka of Cornell University; the spacecraft and project management will be provided by the Johns Hopkins University Applied Physics Laboratory of Laurel, MD. Launch is expected in June 2002.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
PHASE A/B	0.4		8.4							8.8
DEVELOPMENT				34.9	26.0	8.2				69.1
MISSION OPS & DATA ANALYSIS						2.1	3.7	3.0	9.9	18.7
LAUNCH SUPPORT				16.9	19.6	10.8				47.3
TRACKING & DATA SUPPORT						TBD				TBD
TOTAL	0.4		8.4	51.8	45.6	21.1	3.7	3.0	9.9	143.9

Mars Surveyor Program

The Mars Surveyor program is a series of small missions designed to resume the detailed exploration of Mars. The first mission in this program, the Mars Global Surveyor mission, was approved as a new start in FY 1994. The follow-on Mars Surveyor 98 Orbiter and Lander were approved in FY 1995. The Mars Surveyor '01 Orbiter and Lander are to enter development in FY 1998. Future small missions are targeted for launch in the launch windows that occur approximately every two years.

The budgetary estimates below are the amounts indicated in the budget justification within the Space Science section in the Science, Aeronautics and Technology appropriation. The specific write-ups for the Mars Global Surveyor and Mars 98 Orbiter/Lander missions include the amounts for the development of the spacecraft and instruments, two years of mission operations, and launch services. They do not include costs for the use of government facilities and general and administrative support used to carry out the program. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
MARS GLOBAL SURVEYOR	198.0	19.5	13.1	15.9	9.7	9.3	4.4			269.9
98 MARS ORBITER/LANDER	183.2	79.6	30.9	13.6	10.4	7.3	3.5			328.5
01 MARS ORBITER/LANDER		71.2	150.7	126.8	43.2	15.0	14.8			421.7
FUTURE MISSIONS	6.5	37.1	55.7	114.8	208.9	231.2	238.0	233.5	Cont.	1,125.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	387.7	207.4	250.4	271.1	272.2	262.7	260.7	233.5		2,145.7
(ESTIMATED CIVIL SERVICE FTEs)	(62)	(21)	(18)	(19)	(20)	(20)	(19)	(19)	(Cont.)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	4.5	1.7	1.5	1.7	1.8	1.9	1.9	2.0	Cont.	

Mars Global Surveyor

This mission will obtain a majority of the expected science return from the lost Mars Observer mission by flying a science payload comprised of spare Mars Observer instruments aboard a small, industry-developed spacecraft. Launch occurred in November 1996 on a Delta II launch vehicle, and MGS entered Mars orbit in September 1997. The funding estimates provided below do not include the previous expenditures on spare Mars Observer instruments or the amount recovered from the prime contractor after the Mars Observer failure.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	130.7									130.7
MISSION OPS & DATA ANALYSIS	14.7	19.5	13.1	15.9	9.7	9.3	4.4	3.0		89.6
LAUNCH SUPPORT	52.6									52.6
TOTAL	198.0	19.5	13.1	15.9	9.7	9.3	4.4	3.0		272.9

98 Mars Orbiter/Lander

The 98 Mars Orbiter and Lander are the first follow-on missions in the Mars Surveyor program. The Orbiter was launched on a Med-Lite launcher in December 1998, and the Lander was launched on a Med-Lite in January 1999. Lockheed Martin Aerospace, Denver, was selected competitively to develop these spacecraft. The Orbiter carries a color imager and a Pressure Modulater Infrared Radiometer (PMIRR), which was also a Mars Observer payload. The Lander carries a descent imager, a comprehensive volatiles and climate payload, and a Russian LIDAR atmospheric instrument.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	138.7	41.1	13.3							193.1
MISSION OPS & DATA ANALYSIS			8.7	13.2	10.1	7.3	3.5			42.8
LAUNCH SUPPORT	44.5	38.5	8.7							91.7
TRACKING & DATA SUPPORT			0.2	0.4	0.3					0.9
TOTAL	183.2	79.6	30.9	13.6	10.4	7.3	3.5			328.5

'01 Mars Orbiter/Lander

This mission will explore the ancient highlands of Mars to characterize the surface environment in terms of its geologic and aqueous history. The Mars 2001 Orbiter will include Gamma Ray Spectrometer (GRS), Thermal Emission Imaging System (THEMIS), and Mars Radiation Environment Experiment (MARIE). The Mars 2001 Lander will include a Pathfinder/Sojourner-type rover, as well as the Athena Precursor Experiment (APEX), Mars Descent Imager (MARDI), MARIE, Mars Environmental Compatibility Assessment (MECA), and Mars ISPP (In-situ Propellant Production) Precursor (MIP). This instrument complement meets the science requirements of the Office of Space Science, the Office of Human Spaceflight, and the Office of Life and Microgravity Sciences and Applications. The Orbiter and Lander are scheduled to launch in March and April of 2001, respectively, the Orbiter on a Delta 7425 from Vandenberg AFB, and the Lander on a Delta 7925 from Cape Canaveral.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT		67.0	110.7	85.9	18.4					282.0
MISSION OPS & DATA ANALYSIS					9.0	15.0	14.8	15.0		53.8
LAUNCH SUPPORT		4.2	40.0	40.9	15.8					100.9
TRACKING & DATA SUPPORT										
TOTAL		71.2	150.7	126.8	43.2	15.0	14.8	15.0		436.7

Future Surveyor Missions

The Mars Surveyor landers planned in future years -- 2003, 2005 and beyond -- will capitalize on the experience of the Mars Pathfinder lander mission launched in November 1996. The small orbiter to be launched in 2003 will draw on the experience of Mars Global Surveyor and carry other scientific instruments into orbit to complete Mars Global Surveyor's science missions. A Mars sample return mission is being considered for the FY 2005 opportunity.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	6.5	37.1	55.7	114.8	175.8	195.8	210.4	220.1	cont.	
MISSION OPS & DATA ANALYSIS							7.5	13.4	cont.	
LAUNCH SUPPORT					33.1	35.4	20.1		cont.	
TRACKING & DATA SUPPORT										
TOTAL	6.5	37.1	55.7	114.8	208.9	231.2	238.0	233.5		

Space Science New Millennium Spacecraft

The New Millennium program is an advanced development effort started in FY 1996 to demonstrate how complex scientific spacecraft--such as those required for planetary missions--can be built for lower mission costs and have short development times, while still possessing considerable scientific merit. The New Millennium Spacecraft program will enable the introduction of the latest technology advances into spacecraft for planetary and outer solar system explorations. The primary objectives of the program are to increase the performance capabilities of spacecraft and instruments while simultaneously reducing total costs of future science missions, thereby allowing more frequent flight opportunities even under the severe budget constraints of the future. In previous years, NASA and the Department of Defense have funded technology developments which offer extraordinary promise. This precursor work on technologies can now be demonstrated in a series of flight technology demonstration missions occurring at a rate of one every 1.5 years, with the initial flight launched in October 1998.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation. The program is designed as an ongoing program, and funding is included for development and launch of one mission per every one and one half years, beginning in 1998. Launches are generally targeted for small expendable launch vehicles. The budget estimate below does not include the costs for the government facilities and general and administrative support used to carry out the research and development activities. Additional information on the first two missions is provided later in this section. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEEP SPACE 1	77.0	63.9	13.8	1.2						155.9
DEEP SPACE 2	16.4	8.3	1.9	0.8						27.4
FUTURE MISSIONS INCLUDING PROGRAM COSTS		7.1	10.8	14.1	13.1	13.8	14.3	6.1		
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		79.3	26.5	16.1	13.1	13.8	14.3	6.1		
(ESTIMATED CIVIL SERVICE FTEs)	(321)	(1)	(1)	(1)	(3)	(3)	(3)	(3)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	4.0	0.1	0.1	0.1	0.3	0.3	0.3	0.3		

Deep Space 1

Deep Space 1 was selected in FY 1996 as the first New Millennium Program mission. The technology to be validated will include solar electric propulsion, an advanced solar array, autonomous primary navigation, and miniature imaging camera spectrometer. Spectrum Astro was selected in FY 1996 to integrate the spacecraft. DS 1 launched in October, 1998 on a Med-Lite-class Delta launch vehicle, and has partially validated four of the five mission-defining technology demonstrations. These technologies will complete their validation by the end of FY 1999. The supplemental technology development line below contains funding for crosscutting technology development efforts previously managed by the Office of Space Access and Technology.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	64.3	30.9	4.1							99.3
SUPPLEMENTAL TECH DEV (included in Dev)	[13.3]	[1.6]								[14.9]
MISSION OPS & DATA ANALYSIS			9.6	1.2						10.8
LAUNCH SUPPORT	12.6	32.8								45.4
TRACKING & DATA SUPPORT	0.1	0.2	0.1							0.4
TOTAL	77.0	63.9	13.8	1.2						155.9

Deep Space 2

Deep Space 2 was selected in FY 1996 as the second of the series of missions under the New Millennium Program. DS 2 is designed to develop and validate technologies and systems required to deliver multiple small packages to the surface and/or subsurface of Mars using direct entry. Some of the technologies to be validated include power electronics, a microcontroller, flexible interconnects for system cabling and a sample/water experiment. DS 2 was attached to ("piggyback" on) the Mars 98 Lander, launched in January 1999.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT	16.4	7.9	1.5	0.4						26.2
SUPPLEMENTAL TECH DEV (included in Dev)	[2.3]	[1.0]								[3.3]
MISSION OPS & DATA ANALYSIS		0.4	0.4	0.4						1.2
ELV INTEGRATION (included in Dev)		[1.6]								[1.6]
TRACKING & DATA SUPPORT										
TOTAL	16.4	8.3	1.9	0.8						27.4

Space Technology - 3

ST-3 is an interferometry technology validation flight (formerly New Millennium Deep Space-3, included in the flight validation program) to demonstrate the concept of separated spacecraft interferometry. This 6-month flight demonstration, scheduled for launch in 2002, will utilize two spacecraft to validate precision formation flying and space interferometry. This activity has been transferred from the flight validation program to the Astronomical Search for Origins focused program since its purpose is to validate those technologies required for the Terrestrial Planet Finder mission.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT			18.1	12.2	6.2	13.8	6.8			57.1
MISSION OPS & DATA ANALYSIS			0.2	0.7	1.4	4.2				6.5
LAUNCH SUPPORT			9.5	12.5	14.8	13.3				50.1
TRACKING & DATA SUPPORT										
TOTAL			27.8	25.4	22.4	31.3	6.8			113.7

Space Technology - 4

ST-4, the Champollion/Comet Lander mission, will travel to, land on, and study a comet and (potentially) return a sample to Earth. Comets are essentially unaltered icy planetesimals left over from the formation of our solar system over four billion years ago. By studying comets, scientists can probe the beginnings of our solar system. This mission has been transferred from the Flight Validation Program (where it was referred to as the New Millennium Program Deep Space-4 mission), to the Advanced Deep Space Systems focused program because it is a solar system exploration mission.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	BTC	TOTAL
DEVELOPMENT			9.1	25.0	32.3	7.2	10.5			84.1
MISSION OPS & DATA ANALYSIS								3.0	6.0	9.0
LAUNCH SUPPORT					28.4	22.1	7.0			57.5
CHAMPOLLION SCIENCE PAYLOAD [in PL line]			2.3	12.5	28.1	28.9	3.3			75.1
TRACKING & DATA SUPPORT										
TOTAL			11.4	37.5	88.9	58.2	20.8	3.0	6.0	225.8

Earth Observing System

Before the Earth Observing System (EOS) was authorized in November 1990 in the FY 1991 budget as a new start, EOS planning had been in progress for over eight years. The EOS is key to achieving the objectives set forth in the Earth science program plan and the overall goal and scientific objectives of the interagency U.S. Global Change Research Program. EOS is an international science program, drawing upon the contributions of Europe (ESA), Canada, and Japan both in terms of spacecraft and instruments. This extraordinary collaboration is essential to reach the objective of providing comprehensive measurements of the nature of global climate change.

At its outset, the EOS program was based on the flights of two series of large platforms, in addition to platforms from Japan and ESA and instruments carried on Space Station Freedom. The initial estimates provided to Congress focused on the period through fiscal year 2000. The initial estimate of $18-21 billion included development, mission operations, data analysis, launch services, communications, construction of facilities and the amounts carried in the Space Station program for the polar platform's development. In the FY 1992 appropriations process, Congress directed NASA to modify the scope and cost of the program. The cost through FY 2000 was to be reduced by $5 billion, the FY 1993 funding level had to be reduced, and NASA was to examine the feasibility of using smaller platforms. In 1991, the program was restructured to employ five smaller flight series. In 1992, in response to the constrained budget environment, NASA further rescoped the program by implementing a common spacecraft approach for all flights after the first morning (AM-1) spacecraft, increasing reliance on the cooperative efforts of international and other government agencies, and adopting a build-to-cost approach for the first unit of a multiple instrument build. The estimated NASA funding through FY 2000 was further reduced to $8.0 billion in this effort.

In the FY 1995 budget process, the program cost estimate was further adjusted downward by approximately $0.9 billion, of which $0.3 billion reflected an accounting transfer for small business innovative research out of individual programs into a common NASA account, and $0.1 billion reflected the change to lower-cost launch vehicles. The further reductions in program funding were addressed in 1994 through a program rebaselining activity. A number of small spacecraft were introduced into the program flight plans. In addition, alterations were made in flight phasing and accommodations were provided for a follow-on instrument to the enhanced thematic mapper being flown in 1999 on Landsat-7. Funding for the science investigations and data analysis was separated from the algorithms being developed to convert the instrument data into information. This change recognized the close relationship to similar science investigations and data analysis funded in the Earth Science research and analysis account. (The amounts budgeted for EOS science are shown in the table below.) In addition, it was decided to incorporate the development funding for the Landsat-7 into the EOS program in light of the integral ties between the two activities.

In the FY 1996 budget process, the amounts reflected the related program costs for Landsat-7 activities previously funded by the Department of Defense.

The 1997 Biennial Review completed the shift in planning for future missions that began in the 1995 “reshaping” exercise. Emerging science questions drive measurement requirements, which drive technology investments in advance of instrument selection and mission design. Mission design includes such options as purchase of science data from commercial systems and partnerships with other Federal agencies and international agencies. The result is a more flexible and less expensive, approach to acquiring Earth science data.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation except for the amount for the Space Station platform. The amounts below reflect the effects of the rescoping of the EOS program, the impacts of the ZBR, and the inclusion of the estimate for FY 2004. They do not include the costs of the non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Earth Science section.

(Budget Authority in Millions of Dollars)

Earth Observing System	Prior	1998	1999	2000	Subtotal Through FY 2000	2001	2002	2003	2004	Total Through FY 2004
MORNING	1,105.4	71.2	31.8	6.2	1,214.6	3.1				1,217.7
AFTERNOON	454.4	175.9	114.6	119.4	864.3	32.9				897.2
CHEMISTRY	95.7	110.4	130.4	124.7	461.2	93.3	61.5	18.4	7.0	641.4
SPECIAL SPACECRAFT	269.6	96.7	116.2	150.0	632.5	75.5	29.9	13.7	33.5	785.1
QUIKSCAT	35.0	37.9	10.8	1.1	84.8					84.8
LANDSAT 7	348.0	74.3	17.0	2.9	442.2	1.8	1.8	1.8	0.4	448.0
EOS FOLLOW-ON		3.9	4.5	53.9	62.3	194.9	259.8	308.6	315.0	1,140.6
ALGORITHM DEVELOPMENT	343.9	92.3	115.6	127.4	679.2	131.3	132.1	122.5	125.6	1,190.7
TECHNOLOGY INFUSION	76.6	91.9	90.2	77.6	336.3	102.8	120.8	107.0	113.3	780.2
EOSDIS	1,135.0	210.1	261.7	231.5	1,838.3	229.5	227.8	255.0	274.9	2,825.5
SUBTOTAL	3,863.6	964.6	892.8	894.7	6,615.7	865.1	833.7	827.0	869.7	10,011.2
PHASE B	41.0				41.0					41.0
SPACE STATION PLATFORM	104.0				104.0					104.0
EOS SCIENCE	131.3	41.4	46.4	76.0	295.1	69.9	69.8	68.1	71.0	573.9
LAUNCH SERVICES	238.6	39.4	4.2		282.2					282.2
CONSTRUCTION OF FACILITIES	96.7				96.7					96.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	4,475.2	1,045.4	943.4	970.7	7,434.7	935.0	903.5	895.1	940.7	11,109.0
(ESTIMATED CIVIL SERVICE FTEs)	(3,057)	(559)	(476)	(515)		(621)	(674)	(753)	(795)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	205.0	45.8	40.2	46.0		57.2	64.8	75.9	84.1	

EOS New Millennium Program and Technology Infusion

The New Millennium Program (NMP) and Technology Infusion budget reflects a commitment to develop new technology to meet the scientific needs of the next few decades and to reduce future EOS costs. The program objectives are to spawn "leap ahead" technology by applying the best capabilities available from several sources within the government, private industries and universities. The first mission EO-1, has been selected to demonstrate innovative technology to produce Landsat data. The Space-Readiness Coherent Lidar Experiment (Sparcle) is the second EO mission.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	TOTAL
EO-1 (INCLUDES LAUNCH SERVICES)	48.5	65.9	43.5	4.6	0.6				163.1
EO-2 SPARCLE (STS ATTACHED PAYLOAD)		6.8	6.1	2.0	0.8				15.7
NMP TECHNOLOGY & FUTURE FLIGHTS (INCLUDES LAUNCH SERVICES)	9.9	9.0	7.7	34.5	62.4	82.4	69.7	73.0	348.6
ADV. INFORMATION SYSTEMS TECH.			6.5	7.6	9.0	9.5	9.8	9.8	52.2
SENSOR & DETECTOR TECHNOLOGY	11.0	5.5	5.5	8.9	10.0	8.9	5.5	8.5	63.8
INSTRUMENT INCUBATOR	7.2	4.7	20.9	20.0	20.0	20.0	22.0	22.0	136.8
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	76.6	91.9	90.2	77.6	102.8	120.8	107.0	113.3	780.2
(ESTIMATED CIVIL SERVICE FTEs)	(68)	(58)	(30)	(4)	(1)				
CIVIL SERVICE COMPENSATION ESTIMATE (	5.1	4.8	2.5	0.4	0.1				

Earth Probes

The Earth Probes program consists of spacecraft and instrument development to address specific, highly-focused mission requirements in Earth science research. They are complementary to the scientific data-gathering activities carried out within the EOS program. The currently approved Earth probes are the Total Ozone Mapping Spectrometer (TOMS), and the Tropical Rainfall Measuring Mission. The Earth System Science Pathfinder missions will be funded to take advantage of the new technologies in spacecraft and instrument design being developed by other federal agencies and by NASA. The Experiments of Opportunity funding will accommodate opportunities to provide flight instruments and technologies on non-Earth science missions, foreign or domestic, or on airborne experiments. The Lewis and Clark missions were transferred from the Office of Space Access and Technology when that office was dissolved.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation. The program is designed as an ongoing program. The budget estimates immediately below do not include the estimated costs incurred by the international collaborators, mission operations, science costs, related funding included in the Earth Observing System program, NASA civil service work force salary and expenses, use of government facilities and general and administrative support used to carry out the research and development activities. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Earth Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	TOTAL
TOTAL OZONE MAPPING SPECTROMETER (TOMS)	111.4	6.0	4.9	4.9	0.4				127.6
NASA SCATTEROMETER (NSCAT)	210.0								210.0
TROPICAL RAINFALL MEASURING MISSION (TRMM)	245.1	0.9							246.0
TRIANA		0.9	35.0	35.1	2.0	2.0			75.0
LEWIS & CLARK	129.0	1.4	0.1						130.5
UNIVERSITY CLASS EARTH SYSTEM SCIENCE (UNESS)				2.0	4.0	4.0	4.0	4.0	Continues
EARTH SYSTEM SCIENCE PATHFINDERS	15.0	22.8	62.2	75.2	117.5	127.1	119.3	110.5	Continues
EXPERIMENTS OF OPPORTUNITY		2.9	2.5	1.0	0.5	0.5	0.4	0.5	Continues
(ESTIMATED CIVIL SERVICE FTEs)	(840)	(65)	(56)	(57)	(43)	(41)	(42)	(42)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M	56.3	5.3	4.7	5.1	4.0	3.9	4.2	4.4	

Total Ozone Mapping Spectrometer

The TOMS Earth Probes project is a follow-on to the Total Ozone Mapping Spectrometer (TOMS) instrument flown with such great success on the Nimbus-7 spacecraft in 1978. A TOMS instrument was also flown on the Russian METEOR spacecraft in 1991. The TOMS program consists of a set of instruments (flight models 3, 4, 5) and one small spacecraft. Flight model 3 was launched on the TOMS Earth probe spacecraft on July 2, 1996. Flight model 4 was launched on the Japanese ADEOS spacecraft on August 17, 1996. The ADEOS-I spacecraft failed on June 30, 1997. Flight model 5 is currently planned for a cooperative mission with the Russian Space Agency.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	TOTAL
DEVELOPMENT	111.4	6.0	4.9	4.9	0.4				127.6
MISSION OPERATIONS	5.5	2.7	2.7	3.0	2.9	1.6	1.6		20.0
SCIENCE TEAMS	0.9	0.9	0.9	1.0	1.1	1.1	1.0	1.1	8.0
SELV	16.7								16.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	134.5	9.6	8.5	8.9	4.4	2.7	2.6	1.1	172.3
(ESTIMATED CIVIL SERVICE FTEs)	(145)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M	9.7	0.3	0.3	0.4	0.4	0.4	0.4	0.4	

Tropical Rainfall Measuring Mission

The Tropical Rainfall Measuring Mission (TRMM) was launched aboard the Japanese H-II vehicle November 27, 1997. The TRMM development began in FY 1992, after a four-year period of concept studies and preliminary mission definition. The TRMM objective is to obtain a minimum of three years of climatologically significant observations of tropical rainfall. TRMM data will be useful to understand the ocean-atmosphere coupling, especially in the development of El Niño events, which form in the tropics but whose effects are felt globally. The observatory spacecraft was built in-house at the Goddard Space Flight Center. The Japanese built a critical instrument, the Precipitation Radar. Two other instruments are being developed with TRMM program funding, the Visible and Infrared Scanner and TRMM Microwave Imager. In 1992, two EOS-funded instruments were added to the payload, the Clouds and Earth's Radiant Energy System (CERES) and the Lightning Imaging Sensor (LIS). The budget estimates provided below include the costs of accommodating these two instruments on the TRMM observatory. The EOS Data and Information System will have a specific capability for disseminating TRMM data.

(Budget Authority in Millions of Dollars)

	PRIOR	1998	1999	2000	2001	2002	2003	2004	TOTAL
DEVELOPMENT	245.1	0.9							246.0
EOS-FUNDED INSTRUMENTS/SCIENCE/DIS	[50.2]	[8.8]	[12.6]						[71.6]
MISSION OPERATIONS	0.8	10.6	10.9	11.0	9.7	2.2			45.2
SCIENCE TEAMS	2.1	11.2	14.3	14.4	14.9	4.6			61.5
RESEARCH & ANALYSIS-FUNDED SCIENCE	35.4								35.4
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	283.4	22.7	25.2	25.4	24.6	6.8			388.1
(ESTIMATED CIVIL SERVICE FTEs)	(695)	(11)	(10)	(12)	(12)	(2)			
CIVIL SERVICE COMPENSATION ESTIMATE ($M	46.6	0.9	0.8	1.1	1.1	0.2			